Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Daily Precipitation OLYMPEX

Introduction

The GPM Ground Validation Daily Precipitation Olympic Mountain Experiment (OLYMPEX) dataset consists of a single netCDF-4 data file containing estimates of daily precipitation, both rainfall and snowfall amounts, on a 1/32 degree spatial resolution grid covering the extent of the OLYMPEX field campaign region in the Olympic Mountains of the state of Washington. This data product was created for the GPM Ground Validation OLYMPEX field campaign. These VIC precipitation estimates are based on NOAA WSR-88D radar and rain gauge data incorporated in NOAA's National Severe Storms Laboratory (NSSL) local gauge bias-corrected radar quantitative precipitation estimation (QPE) model (product Q3GC) and the Mountain Mapper QPE model (product Q3MM). The VIC hydrology model was used to invert the snow water equivalent (SWE) values to derive precipitation through adjustment of the precipitation-weighting factor on a grid cell by grid cell basis. The VIC precipitation data are available from October 1, 2015 through April 30, 2016.

Citation

Cao, Qian and Dennis P. Lettenmaier. 2018. GPM Ground Validation Daily Precipitation OLYMPEX [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GPMGV/OLYMPEX/MULTIPLE/DATA301

Keywords:

NASA, GHRC, GPM, OLYMPEX, Washington, precipitation, ASO, NSSL MRMS, LiDAR, WSR-88D, snow, rain, precipitation amount, snowfall amount, rainfall amount

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which launched on February 27, 2014. The

instrument validation effort included numerous GPM-specific and joint agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. More information about the GPM mission is available at https://pmm.nasa.gov/GPM/.

One of the GPM Ground Validation field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest. The goal of OLYMPEX was to validate rain and snow measurements in mid-latitude frontal systems as they move from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting, and climate data. The campaign consisted of a wide variety of ground instrumentation, several radars, and airborne instrumentation monitoring oceanic storm systems as they approached and traversed the Peninsula and the Olympic Mountains. The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information is available from the NASA GPM Ground Validation web site https://pmm.nasa.gov/olympex and the University of Washington OLYMPEX web site http://olympex.atmos.washington.edu/.

Figure 1: OLYMPEX Domain
(Image Source: https://pmm.nasa.gov/OLYMPEX)

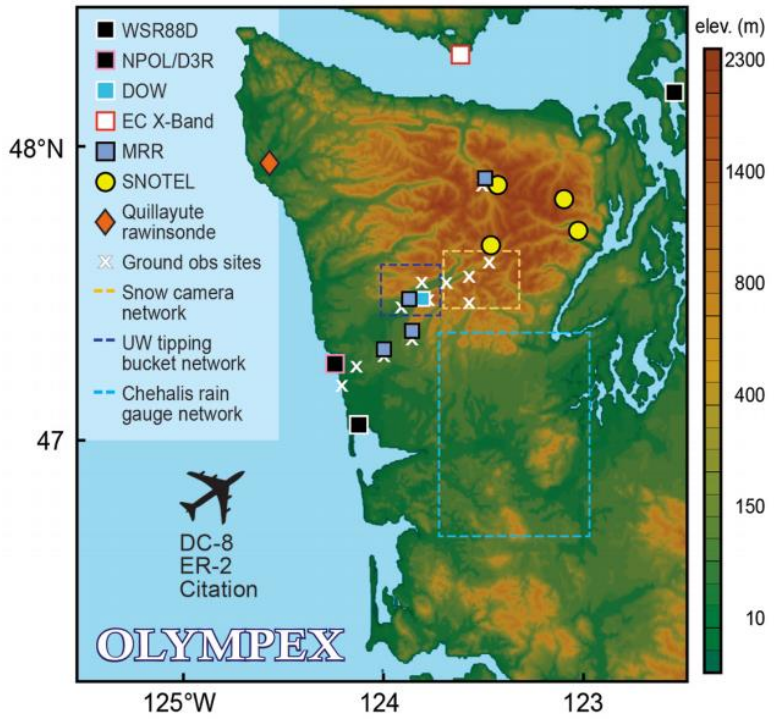

Figure 2: OLYMPEX Field Locations
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Product Description

The GPM Ground Validation Daily Precipitation OLYMPEX dataset consists of daily precipitation estimates on a 1/32° spatial resolution over the OLYMPEX domain which includes the Olympic Peninsula plus the Chehalis River basin. This VIC precipitation product is intended to provide a best estimate of precipitation throughout the OLYMPEX study area and is based on a combination of observations and model outputs. The VIC precipitation product is constructed using two different strategies to estimate precipitation, one for low and one for high elevations to produce one product most suitable data for validation of GPM and other rain products.

At low elevations, where radar precipitation estimates are of better quality and rain gauges are relatively abundant, two radar-gauge products of radar quantitative precipitation estimation (QPE) produced by NOAA's National Severe Storm Laboratory (NSSL) are used. The local gauge bias-corrected radar (Q3GC) product, which is bias corrected using 120 NOAA Hydrometeorological Automated Data System (HADS) gauges, and the Mountain Mapper QPE (Q3MM) product, which interpolates HADS precipitation measurements for areas with poor radar quality. The NSSL products rely on WSR-88D radar data from two stations, Langley Hill on the coast of Washington and Camano Island in the northern Puget Sound. These NSSL products are combined and additional gauge data from primarily lower elevation stations collected during OLYMPEX are incorporated. The additional gauges are from NOAA's Cooperative Observer Network (COOP), the Community Collaborative Rain,

Hail and Snow Network (CoCoRaHS), Remote Automatic Weather Stations (RAWS), the Automated Surface Observing System (ASOS), and National Weather and Climate Center's Snow Telemetry (SNOTEL) sites. Care was taken to remove any repeated stations as there was overlap between the RAWS and HADS gauges.

In the interior of the Olympic Mountains at higher elevations (>500 meters) there can be significant winter snow accumulations and few precipitation observations. Radar coverage is restricted due to terrain blockage. At these mountainous regions, precipitation is derived using the VIC hydrology model (Liang et al. 1994) which is used to invert snow water equivalent (SWE) values estimated from snow depth maps obtained during two flights of the NASA JPL Airborne Snow Observatory (ASO) Lidar instrument on 8-9 February 2016 and 29-30 March 2016. The ASO snow depth maps are input to the VIC model and precipitation is derived by adjustment of the precipitation-weighting factor on a grid cell by grid cell basis.

The SWE-based winter precipitation estimates for the high-elevation areas are then merged with the radar–gauge precipitation estimates derived for the lowlands into this one product. Daily estimates of precipitation (unit: mm/day), rainfall (unit: mm/day), and snowfall (unit: mm/day) are constructed at 1/32° spatial resolution over the OLYMPEX domain.

More detailed information about the methodology used to create this data product can be found in Cao et al., 2017.

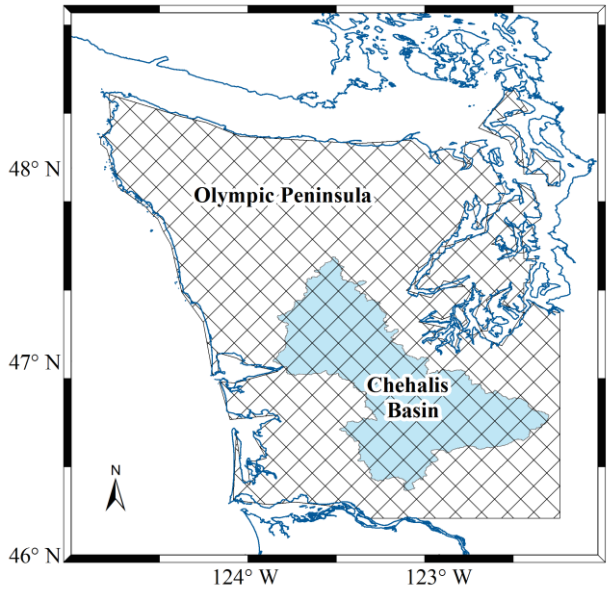

Figure 3: Map of the Olympic Peninsula; VIC precipitation domain is cross hatched.

Investigators

Qian Cao

University of California in Los Angeles
Los Angeles, California

Dennis P. Lettenmaier
University of California in Los Angeles
Los Angeles, California

Data Characteristics

The GPM Ground Validation Daily Precipitation OLYMPEX data file is available in netCDF-4 format at a Level 4 processing level. More information about the NASA data processing levels are available on the NASA Data Processing Levels website. Table 1 shows the characteristics of the data file.

Table 1: Data Characteristics

Characteristic	Description
Platforms	none
Instrument	Data from the following instruments are used in producing this precipitation product: ● Ground station gauges throughout the region at lower elevations (HADS, RAWS, COOP, CoCoRaHS, ASOS) ● Airborne Lidar - JPL Airborne Snow Observatory (ASO) ● Ground-based NOAA WSR-88D at Langley Hill and Camano Island ● National Weather and Climate Center's Snow Telemetry (SNOTEL) sites
Projection	n/a
Spatial Coverage	N: 48.484, S: 46.203, E: -122.391, W: -124.734 (Washington)
Spatial Resolution	1/32 degree grid
Temporal Coverage	October 1, 2015 - April 30, 2016
Product Frequency	1 day
Parameter	Precipitation amount, rainfall amount, snowfall amount
Version	1
Processing Level	4

File Naming Convention

The GPM Ground Validation Daily Precipitation OLYMPEX dataset has the file naming convention shown below. There is only one data file for this dataset. The file is in netCDF-4 format.

Data files: olympex_precip_reconstructed.nc

Table 2: File naming convention variables

Variable	Description
.nc	netCDF-4 file format

Data Format and Parameters

The GPM Ground Validation Daily Precipitation OLYMPEX dataset consists of one netCDF-4 data file containing daily total precipitation amount, rainfall amount, and snowfall amount measurements from October 1, 2015 through April 30, 2016. Table 3 describes the data parameters in the data file.

Table 3: Data Fields

Field Name	Description	Data Type	Unit
lat	Latitude	double	Degrees North
lon	Longitude	double	Degrees East
precipitation	Precipitation amount for each day defined as 0000 PST - 2400 PST (UTC-08:00)	float	mm/day
rainfall	Rainfall amount for each day defined as 0000 PST - 2400 PST (UTC-08:00)	float	mm/day
snowfall	Snowfall amount for each day defined as 0000 PST - 2400 PST (UTC-08:00)	float	mm/day
time	Days since 2015-10-01 00:00:00 UTC	double	days

Algorithm

Details of product development approach is provided in Cao et al., 2017. Here we mention a few important points and direct the reader to other notable publications.

The SNOTEL temperature data used did show warm biases at cold temperatures that were corrected. More information about these biases and the correction methodology is available in Currier et al., 2017. More information about the NSSL products and the algorithms used in development see Zhang et al., 2011, 2016.

The precipitation radars suffer from terrain obstruction in the Olympic region. To indicate the potential uncertainties of radar precipitation related to these beam obstructions, the NSSL developed a mosaic Radar Quality Index (RQI) product ranging levels of uncertainty from 0 to 1 (from high to low). This product was used to replace elevations higher than 500 meters and for better spatial continuity. More information about this product and how it was used can be found in Cao et al., 2017.

The NASA OLYMPEX group quality controlled the OLYMPEX rain gauge data. The average of each pair of the NASA dual-platform tipping buckets measurements was taken if no quality flags for malfunctions or ice/snow, as well as if their daily precipitation differed by less than 10% for days when precipitation exceeds 10 mm. To screen for outliers, a simple quality control was performed for all gauges. Finally, if precipitation measurements exceeded the maximum of surrounding four gauges by 100%, it was flagged as missing data. More information can be found in Houze et al., 2017.

Quality Assessment

The OLYMPEX precipitation product has been compared to both IMERG (version 04A) and its Japanese counterpart GSMaP's (version 04B) satellite-only precipitation products. Both tend to underestimate winter precipitation, by 41% and 28%, respectively, over the entire OLYMPEX domain from 1 October 2015 to 30 April 2016. The underestimation is more pronounced for the orographically enhanced mountainous regions in the interior of the OLYMPEX domain, by 57% and 48%, respectively. In contrast, IMERG and GSMaP storm interarrival time statistics are quite similar to those estimated from gridded observations.

Software

This data file is in netCDF-4 format, so no software is required to view; however, Panoply can be used to easily view these data.

Known Issues or Missing Data

If precipitation measurements exceeded the maximum of surrounding four gauges by 100%, it was flagged as missing data.

The precipitation estimates in this data product were most affected by errors in both observations and the model parameters used in the snowpack reconstructions for the interior of the domain; however, these errors have been mitigated as discussed in Section 3.2.2 of Cao et al., 2017. This VIC precipitation product was also affected by the estimates of the temperature lapse rates as these estimates can have great spatial variability over complex terrain; therefore, grid temperature values were estimated by interpolating residuals from 20 local temperature stations. More information about known issues within this data product can be found in Cao et al., 2017.

References

Cao, Q., T. Painter, W. Currier, J. Lundquist, and D. Lettenmaier, 2017: Estimation of precipitation over the OLYMPEX domain during winter 2015-2016. J. Hydrometeor. doi:10.1175/JHM-D-17-0076.1, in press.

Currier, William Ryan, Theodore Thorson, and Jessica D. Lundquist (2017): Independent Evaluation of Frozen Precipitation from WRF and PRISM in the Olympic Mountains. *Journal of Hydrometeorology*, 18, 2681-2703. doi: https://doi.org/10.1175/JHM-D-17-0026.1

Houze, Robert A. Jr., Lynn A. McMurdie, Walter A. Petersen, et al. (2017): The Olympic Mountains Experiment (OLYMPEX). *American Meteorological Society BAMS*, Oct 2017, 2167-2188. doi: https://doi.org/10.1175/BAMS-D-16-0182.1

Painter, Thomas H., Daniel F. Berisford, Joseph W. Boardman, et al. (2016): The Airborne Snow Observatory: Fusion of scanning lidar, imaging spectrometer, and physically-based

modeling for mapping snow water equivalent and snow albedo. *Remote Sensing of Environment*, 184, 139-152. doi: https://doi.org/10.1016/j.rse.2016.06.018

Sinclair, Scott and Geoff Pegram (2005): Combining radar and rain gauge rainfall estimates using conditional merging. *Atmospheric Science Letters*, 6, 19-22. doi: http://dx.doi.org/10.1002/asl.85

Zhang, Jian, Kenneth Howard, Carrie Langston, Brian Kaney, et al. (2016): Multi-Radar Multi-Sensor (MRMS) Quantitative Precipitation Estimation: Initial Operating Capabilities. *American Meteorological Society BAMS*, Apr 2016, 621-638. doi: https://doi.org/10.1175/BAMS-D-14-00174.1

Zhang, Jian, Kenneth Howard, Carrie Langston, Steve Wasiloff, et al. (2011): National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *American Meteorological Society BAMS*, Oct 2011, 1321-1338. doi: https://doi.org/10.1175/2011BAMS-D-11-00047.1

Related Data

All data from other instruments collected during the OLYMPEX field campaign are related to this dataset. Other OLYMPEX campaign data can be located using the GHRC HyDRO 2.0 search tool.

Contact Information

To order these data or for further information, please contact:

NASA Global Hydrology Resource Center DAAC
User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

Created: February 1, 2018